

Field-Widened Michelson Interferometer as the Spectral Discriminator in a 1064 nm HSRL

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Information on particle size distributions is a key necessity for reducing the uncertainty in climate models caused by clouds and aerosols. Attempts have been made to improve these measurements, however these methods have important limitations. Sun photometers are able to provide information on particle size distributions, but they are not able to provide information on vertical structure. Existing lidar systems can provide high resolution vertical measurements of aerosol optical of the whole aerosol population, but, because these systems operate at a single wavelength, they do not provide information about the aerosol distribution itself.

Here we describe a model for a field-widened Michelson interferometer (FWMI) as the aerosol signal blocking filter for the 1064 nm channel of an existing Nd:YAG HSRL system operating at 532 nm, allowing for HSRL measurements at two wavelengths. HSRL systems are used to measure the optical properties of clouds and atmospheric aerosols with absolute calibration and high vertical resolution, useful for the study of air quality, cloud physics, and the direct and indirect aerosol effects. HSRL systems are often implemented using frequency doubled Nd:YAG lasers. These systems have an HSRL channel at 532 nm, with an iodine vapor cell as the aerosol spectral discriminator, and a standard backscatter lidar channel at 1064 nm. The FWMI described here provides sufficient angular acceptance of the received signal without low losses suffered in the iodine vapor cell. The robust measurements of aerosol optical properties at two wavelengths provided by this instrument would allow for measurement of the Angstrom exponent, and therefore provide information on aerosol size distributions.

Our model FWMI consists of one fused silica arm and one air arm supported with a metal spacer. The air arm allows for pressure and temperature tuning of the FWMI. The optical path difference between the two arms is optimized so that the transmitted signal minimizes the aerosol backscatter signal while retaining much of the molecular backscatter signal. This transmitted channel would be used as the molecular channel, while the reflected channel would be used for the combined channel. We analyze performance of the FWMI under various errors including locking error, wavefront error, overall interferometer tilt error, single mirror tilt error, temperature variation, and pressure variation. Our model shows a performance of 17 dB attenuation of the aerosol signal leakage in the molecular channel. Addition of this 1064 nm HSRL channel to an existing 532 nm HSRL system would provide information on aerosol particle size distributions that are critical for reducing uncertainty in atmospheric models.